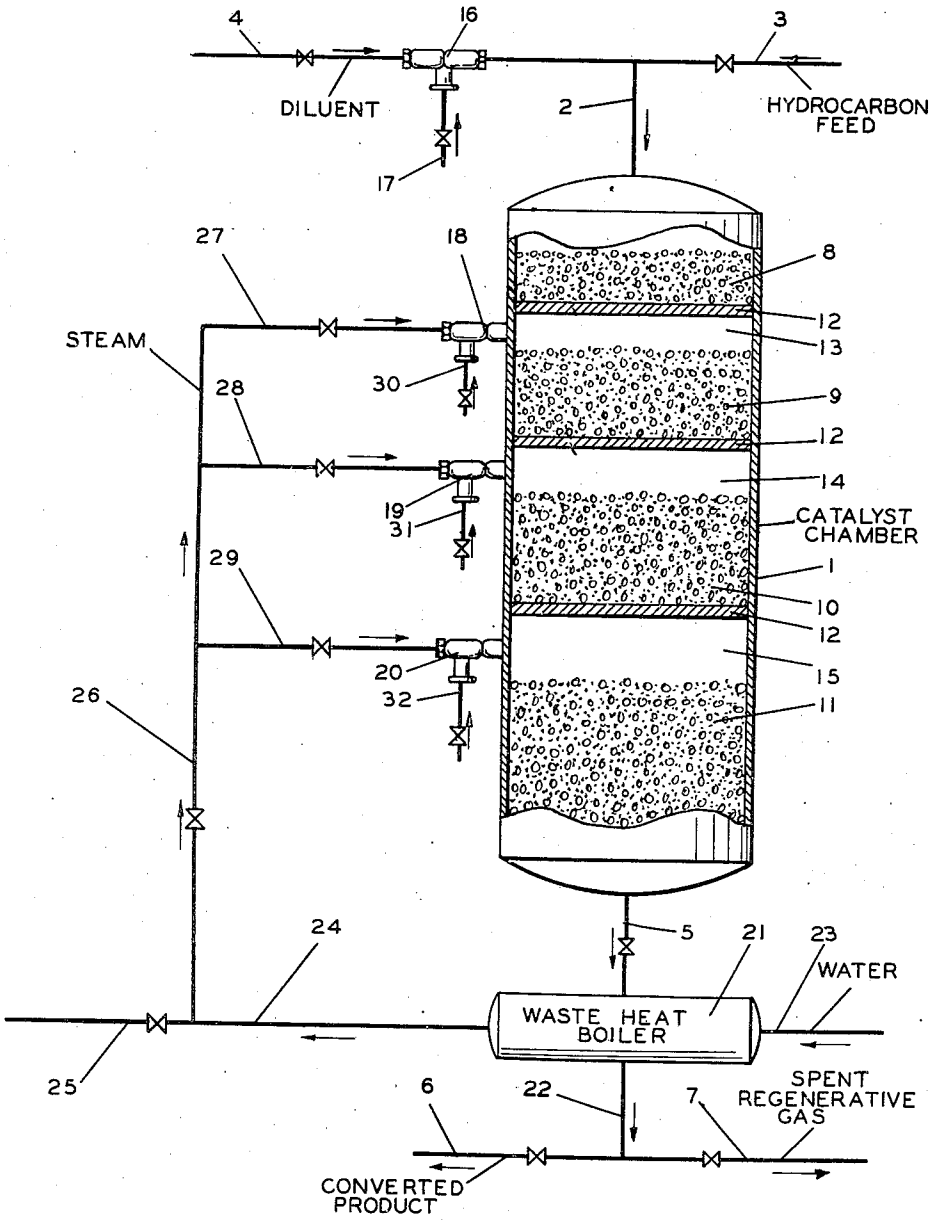
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CATALYST REGENERATION

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CATALYST REGENERATION

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This invention relates to catalytic conversion of hydrocarbons and more particularly to catalytic conversion of hydrocarbons with provision for regenerating or reactivating the catalyst after it has become so laden on-stream with combustible carbonaceous material such as carbon that the rate of conversion is no longer economical. Still more particularly it relates to an improved process and apparatus for reactivating such a catalyst in situ.

The present invention is an improvement over the catalyst regeneration disclosed in application Serial No. 414,850, filed October 13, 1941.

In catalytic cracking operations where high carbon deposits are encountered, large volumes of air are required to burn off the carbon and regenerate the catalyst. With chamber-type operation and stationary catalyst beds, it is essential that the regenerative gases be handled at pressures above atmospheric in order to decrease the diameter of conveying conduits and decrease differential pressure drop across the system.

The air compression required is relatively costly both as to initial investment and operating cost. Also, a diluent such as steam or flue gas must be used with the air to limit the temperature to a reasonable maximum in burning off the carbon.

As it is generally advantageous to recover the heat of regeneration by means of waste heat boilers, the present invention contemplates, among other things, the use of steam from such boilers to inject combustion air into the catalyst chambers. Steam is generated in waste heat boilers, which waste heat boilers serve as a quenching means for the conversion step and recover the heat from the spent regenerative gases. The steam may acquire a pressure of 200 pounds per square inch, for example, and, under this pressure, it is forced through a steam jet into the catalyst chamber. The steam in going through the steam jet has an aspirating action and draws air or other free oxygen containing gas in with the steam, which air supports combustion in the respective catalyst beds.

One of the main advantages of the present invention resides in the fact that it eliminates certain expensive items of equipment, including conventional compressors. The present invention eliminates the need for such items of equipment and provides a simplified and more efficient method and arrangement of apparatus for effectively carrying out the regeneration of spent catalyst. It will be evident to those skilled in the art that the practice of my invention greatly reduces the investment cost, minimizes replacement expenses, and requires relatively low maintenance and operation expense, both in equipment and in necessary personnel to handle the same.

In operation, superheated steam, at 200 pounds per square inch and 900° F., for example, with inducted air or other free oxygen containing gas, is injected into the top of the catalyst chamber, the mixture of steam and air being at high enough temperature, such as 800° F., and high enough air content, such as 10% by volume, to initiate combustion of the carbon deposit. The steam expands through the jet at high velocity, the kinetic energy resulting therefrom is sufficient to inject a mixture of steam and air into the chamber, whose static pressure is less than the initial steam pressure. The spent reactivated gases and steam are removed from the bottom of the catalyst chamber. Where the catalyst chamber employed is divided into a plurality of compartments, auxiliary jets using steam and air at lower temperatures than those indicated above are used to promote combustion of deposited carbon in subsequent compartments, since admixture of the secondary regenerative gas with the hot gas from initial combustion produces a mixture at high enough temperatures to ignite the remaining carbon. In effect, higher free oxygen content is permissible in cool secondary regenerative gas, and the total amount of gas handled is decreased.

It is a primary object of the present invention to employ the pressure of a diluent gas, such as steam, to maintain the required pressure in a catalytic process and further to pass the steam under pressure through a jetting device and by the aspirator action of the jetting device, draw and then inject the necessary free oxygen containing gas into the process, to support combustion during the regenerative step.

It is a further object of this invention to provide a system of the character indicated which is less expensive in initial, maintenance, and operating costs than similar systems for regenerating spent catalysts that have been employed heretofore.

It is a still further object of the invention to conserve on the amount of critical metals employed in carrying out a catalyst regeneration process.

Other objects and advantages will appear from the description as it continues and from the annexed drawing which is a diagrammatic view of the process.

Referring to the drawing, a catalyst chamber 1

is provided at its top with an inlet 2. A suitable hydrocarbon feed stock is supplied to inlet 2 during the hydrocarbon conversion procedure by a line 3. Reactivating gas is supplied to the top of the catalyst chamber by way of a line 4 and inlet 2 in the course of the regeneration of the spent catalyst. A discharge line 5 is provided at the bottom of the catalyst chamber for removing converted hydrocarbons by way of a line 6 or alternatively for removing spent reactivating gases by way of a line 7.

For the purpose of illustration only, I have shown catalyst chamber 1 as being divided into a plurality of compartments or zones 8, 9, 10 and 11 of progressively increasing volume reading downwardly. It is to be understood that my invention may be effectively practiced whether the catalyst chamber is divided into a plurality of compartments, as illustrated, or whether it consists of a single compartment. Furthermore, while four compartments or zones are denoted in the drawing, it will be apparent that any desired suitable number of zones may be employed with equal success. The sections are separated by foraminate members 12 extending across the interior of the catalyst chamber to permit the free passage of gas through each bed of solid catalyst material that is supported on and above each member 12.

As was indicated above, a diluent, such as super-heated steam, with inducted air is supplied to the top of the chamber at desired pressure and temperature. The diluent, preferably steam, is conducted through line 4 to a jetting device or injector 16. A line 17 transmits a free oxygen containing gas, such as air, to jetting device 16. As the steam is jetted through device 16, it draws or inspirates air from line 17, the steam and air being thoroughly mixed within device 16 and then aspirated into upper zone 8 of the catalyst chamber. It will be apparent that the mixture of steam and air may be forced into the chamber by virtue of the kinetic energy developed while these materials are being passed through jetting device 16.

Mixing zones 13, 14, and 15 are provided between the catalyst beds. The hot gases issuing from top zone 8 are admixed with fresh reactivated gas and steam that are introduced through jetting devices or injectors 18, 19, and 20 as the gas and steam pass downwardly through catalyst zones 9, 10, and 11, respectively. The resulting mixture of fluid materials in the various zones at desired temperature, volume, and oxygen content passes through each lower bed successively and burns the carbon deposited on the spent catalyst to thereby reactivate the catalyst. It will be evident that the temperature developed in the various zones should be such as not to exceed the safe limits of the materials of the chamber, and further, so as not to injure the catalyst itself in the course of reactivation. The recommended range of temperatures for safely and efficiently operating the system is generally between 700° and 1500° F.

The effluent products, when the process is on the conversion cycle, or spent regenerative gases, when the process is on reactivation, pass through the waste heat boiler 1, leave through the line 22 and then pass to either line 6 or 7, depending on which cycle the process is operating. Water from a line 23 enters the waste heat boiler 21, wherein it is converted to steam and leaves through the line 24. Line 24 divides into two lines 25 and 26 respectively. Line 25 carries excess steam, that may be generated in the practice of this invention, to other uses. Line 25 may be employed to supply additional steam from a suitable source when such additional steam is required in the process. Valved line 26 conducts the steam to valved lines 27, 28, and 29 which in turn connect into the jetting devices 18, 19, and 20, respectively. Connecting into each of these jetting devices are the valved air lines 30, 31, and 32. The steam passing through the jetting devices draws in air through the lines 30, 31, and 32 and mixes the air with the steam before the mixture passes into the zones 13, 14, and 15. The action of jetting devices 18, 19, and 20 is the same as that of jetting device 16, described above.

It is thought that the operation is obvious without any further detailed description thereof. The operation of the catalyst chamber, both on conversion and reactivation is fully discussed in Serial No. 414,850, filed October 13, 1941, and since the catalyst chamber is the same, reference is made to this application for a full understanding of its operation.

The jetting devices 16, 18, 19, and 20 are a standard article of commerce, available from any number of sources making equipment to handle steam generation and distribution, and applicant makes no claim of novelty for the specific jetting devices employed. The free oxygen containing gas supplied by lines 17, 30, 31, and for 32 may be either at atmospheric or superatmospheric pressure, as desired. The pressure of this gas before it is admitted into the corresponding jetting devices should be such that pressure of the combined diluent, such as steam and air, will be sufficient to carry out the purposes of this invention.

It is recommended and within the purview of this invention to recycle spent regenerative gas from line 7 to lines 17, 30, 31, and for 32 when it is found that the conditions for operating the catalyst chamber in regenerating spent catalyst warrants the use of more diluent than that normally supplied to the catalyst chamber downstream of the individual jetting devices.

From the foregoing, it is believed that the method and apparatus of the present invention will be readily comprehended by persons skilled in the art. It is to be clearly understood, however, that various changes in the apparatus herein shown and described and in the method of fabricating the same, as outlined above, may be resorted to without departing from the spirit of the invention as defined by the appended claims.

I claim:

1. A process for regenerating solid catalytic material contaminated with combustile carbonaceous material deposited during conversion of hydrocarbons, in which oxygen containing regenerating gases admixed with a steam diluent is contacted with said catalytic material under combustion conditions in a regeneration zone to removed said carbonaceous material, wherein the catalytic material in said regeneration zone is arranged in a series of beds having free spaces therebetween, and wherein oxygen-containing regenerating gas is introduced into each of said beds under combustion conditions to effect regeneration thereof, which comprises flowing hot combustion gases from said regeneration zone in heat exchange with a stream of water, generating superheated steam at elevated pressure thereby, flowing said superheated steam through a plurality of injector means each communicating with

a source of free oxygen-containing regenerating gas, admixing said oxygen-containing regenerating gas with said steam by the inspirating action of said steam in passing through said injector means, and directly injecting said mixture into each of said free spaces whereby intimate mixing thereof with combustion products flowing from the preceding bed and distribution into the succeeding bed occurs, and maintaining combustion conditions in each of said beds in order to effect combustion of the carbonaceous material therein.

2. A catalyst regeneration system which comprises a catalyst chamber, a series of spaced catalyst beds in said chamber, a plurality of injector means each positioned immediately adjacent to a corresponding space between said beds, one of said injector means being positioned ahead of the first bed in said series to directly introduce oxygen-containing regeneration gas under combustion conditions into the spaces between said beds and ahead of the first of said series of beds, means for removing hot combustion gases from said chamber, a waste heat boiler, means for flowing said hot combustion gases through said waste heat boiler in heat exchange with a stream of water introduced therein to generate steam under pressure, means for flowing said steam through said injector means, a source of free oxygen-containing gas communicating with said injector whereby said gas is admixed with said steam by the inspirating action thereof to form the oxygen-containing regeneration gas and is injected into said spaces in a manner to effect intimate mixing of said steam and oxygen-containing gas with the products of combustion from the preceding bed in said spaces and ahead of said first bed by the kinetic energy of said steam.

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